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Case studies of the effects of vestibular stimulation on reading skills in children with learning disability and accompanying vestibular dysfunction

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CASE STUDIES OF THE EFFECTS OF VESTIBULAR STIMULATION ON READING SKILLS IN CHILDREN WITH LEARNING DISABILITY AND ACCOMPANYING VESTIBULAR DYSFUNCTION

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By

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ABSTRACT

CASE STUDIES OF THE EFFECTS OF VESTIBULAR STIMULATION ON READING SKILLS IN CHILDREN WITH LEARNING DISABILITY AND ACCOMPANYING VESTIBULAR DYSFUNCTION
by Shelley C. McKeone

The purpose of this study was to examine the relationship between vestibular stimulation and reading skills in two children who have learning disability and vestibular dysfunction.

Two boys aged eight and twelve were given pre- and posttests utilizing the Woodcock-Johnson Battery to test reading skills and the Southern California Postrotary Nystagmus Test for vestibular dysfunction. Subjects underwent 30 minutes of vestibular stimulation three times per week. The vestibular stimulation consisted of sliding, jumping, and rolling activities. Subjective notes were kept for each subject to record observable behaviors and changes which occured in treatment. No reading activities were used as therapy. Discernible change was evident in postrotary nystagmus and reading skills in both subjects following the intervention period. These findings demonstrate a positive association between vestibular stimulation and reading skills in these subjects who have learning disability and accompanying vestibular dysfunction.

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CHAPTER ONE

INTRODUCTION

Purpose

This study examined the relationship of vestibular stimulation to reading skills in children who have learning disabilities. The purpose of the study was to determine if a program of vestibular stimulation would increase the reading comprehension, reading recognition, and word attack skills of children with learning disability and accompanying vestibular dysfunction.

Statement of the Problem

The ability to read is a large part of the academic world and everyday life. Children need to possess good reading skills to progress successfully through the educational system and perform activities of daily living.

Vestibular function has been related to an individual's ability to read (DeQuiros, 1976). Ayres (1972) stated that reading difficulty often points to involvement of oculomotor and vestibular functions. Children who have sensorimotor delays that involve the vestibular system often have learning disabilities associated with reading dysfunction. Children who have poor vestibular sensory processing functions may also have difficulty following an object that is moving within their visual field; their eyes may exhibit jerky movements instead of smooth ones (Ayres, 1979). These visual motor problems may make reading a single line of print laborious and effect the learning process in the educational system.

Ayres (1972a) has demonstrated that vestibular stimulation can increase reading ability in children with learning disability. It is hypothesized that vestibular stimulation can alleviate the problem by integrating the nervous system, rather than working on the symptoms as is done in remedial reading classes. Additional research is needed to corroborate or refute this hypothesis.

Objectives

The objective of this study was to determine the effects of vestibular stimulation on reading comprehension, reading recognition, and word attack skills in children, whose first language is English and who demonstrated reading difficulties and vestibular system dysfunction.

Questions

The questions generated for this study were:

1. Does vestibular stimulation increase reading comprehension in children with learning disability and accompanying vestibular dysfunction?
2. Does vestibular stimulation increase reading recognition in children with learning disability and accompanying vestibular dysfunction?
3. Does vestibular stimulation increase word attack skills in children with learning disability and accompanying vestibular dysfunction?

Definitions

Definitions formulated for this study were:

Learning Disability: difficulty in learning to read, write, compute, or do schoolwork that cannot be attributed to impaired sight or hearing, or to mental retardation (Ayres, 1979, p. 182).

Letter Recognition: the ability of an individual to recognize letters of the alphabet as measured by the Woodcock-Johnson Battery.

Nystagmus: a series of automatic, back and forth eye movements (Ayres, 1979, p. 183).

Postrotary Nystagmus: the horizontal reflex movement of the eyes following an abrupt stop after a series of rotations at a constant velocity (Ayres, 1978, p. 40).

Reading Comprehension: the ability of an individual to understand what he has read as measured by the Woodcock-Johnson Battery.

Reading Difficulty: a condition which interferes with the ability to understand what is being read.

Reading Recognition: the ability to recognize and read words and letters, as measured by the Woodcock-Johnson Psycho-educational Battery.

Sensory Integration: the organization of sensory input for use. Through sensory integration the many parts of the nervous system work together so that a person can interact with the environment effectively (Ayres, 1979, p. 184).

Sensory Integrative Dysfunction: an irregularity or disorder in brain function that makes it difficult to integrate sensory input (Ayres, 1979, p. 184).

Sensory Integrative Therapy: treatment involving sensory stimulation (vestibular, proprioceptive, and tactile) and adaptive responses according to a child's neurological needs. The goal of therapy is to improve the way the brain processes and organizes sensations (Ayres, 1979, p. 184).

Southern California Postrotary Nystagmus Test: a test designed to provide a standardized procedure for measuring the degree of normalcy of a child's postrotary nystagmus (Ayres, 1975, p. 1).

Vestibular Dysfunction: a disorder of the vestibular system in which the brain underreacts or overreacts to vestibular input (Ayres, 1979).

Vestibular Stimulation: stimulation of the receptors in the three semicircular canals and otoliths of the vestibule within the vestibular apparatus.

Vestibular System: the sensory system that responds to the position of the head in relation to gravity and accelerated and decelerated movement (Ayres, 1979, p. 185).

Woodcock-Johnson Psycho-educational Battery: a wide range comprehensive set of tests for measuring cognitive ability, achievement and interest (Woodcock-Johnson, 1977).

Word Attack: the ability to read a nonsense word (e.g.: nat, ib) as measured by the Woodcock-Johnson Psycho-educational Battery.

Assumptions

Assumptions held by the researcher for this study were:

1. During the eight week period of the study, the subjects did not participate in any activities that would significantly affect the vestibular system.
2. During the eight week period of the study, the subjects did not engage in any extracurricular activity to enhance reading, that would significantly affect the outcome of the study.
3. Since the subjects were screened for visual acuity with or without glasses, poor visual acuity would not be a factor in the reading disability.
4. The researcher's interaction with each child was consistent and did not significantly affect the subject's motivation and participation in the study.
5. Subjects would tolerate the treatment techniques (jumping, rolling, and sliding) without becoming nauseated and become more accustomed to them during the time of the study.

Limitations

A limitation identified for this research was the limited experience of the researcher in administering the standardized tests used: the Southern California Postrotary Nystagmus Test, the Woodcock-Johnson battery, and the limited experience of the researcher in applying the treatment techniques of rolling, jumping, and scooterboard activities. Further, it was not possible to account for all of the variables that may have affected the vestibular system and the reading abilities of the subjects. The vestibular stimulation activity program was limited to eight weeks, while sensorimotor therapy may be required for up to six months, for maximum results. Another limitation is the lack of generalizability of the results to the entire population because of the limited number of subjects used. There may have been difficulty in the researcher's ability to maintain objectivity during data collection and analysis due to the research methodology used. It was not possible to control for maturation or spontaneous growth factors that may have an impact upon the child's ability to read.

Significance of the Study

Individuals are faced every day with the need to have adequate reading skills to survive in the world. The American educational system is based primarily on the ability to read written communication. Reading is a task faced by individuals from preschool years throughout their lifetime.

Sensorimotor disorders (such as vestibular dysfunction) are present in some children with learning disabilities and can affect the normal development of competencies in learning such as reading (White, 1979). Children with learning disabilities that include difficulties with reading are at a disadvantage in this area. Children with such learning disabilities may fall behind their peers educationally which may have detrimental effects on the children as they may not progress normally through the educational system.

It has been demonstrated that vestibular stimulation among other sensory stimulation techniques can have a positive effect on children with learning disabilities. It is hoped that this study will further contribute to the current research which investigates the effectiveness of vestibular stimulation to increase reading skills in children with learning disability.

CHAPTER TWO

LITERATURE REVIEW

Sensory Integration Theory

The theory of sensory integration was developed by Dr. A. Jean Ayres. Sensory integration is defined as the ability to organize sensory information for use (Ayres, 1972). If a child has hypo- or hyperreactivity to sensory stimuli this may indicate that the central nervous system is not inhibiting or processing this sensory information accurately. Therefore the motor output from the child will not be accurate (Quirk, 1990).

In this theory, Dr. Ayres stated that disordered sensory integration accounts for some aspects of learning disorders. She hypothesized that by enhancing sensory integration, academic learning may become easier for those children with learning disorders (Ayres, 1972). Ayres stated that learning disabilities are a result of some neural dysfunction in the brain; she proposed sensory integration therapy as a mode for helping children with learning disability by enhancing the brain's ability to integrate and organize multiple stimuli coming in from the environment.

Sensory integration has three components with over arching postulates. The first postulate states

> that learning is dependent on the ability of normal individual to take in sensory information derived from the environment and from movement of their bodies, to process and integrate these sensory inputs within the central nervous system, and to use this sensory information to plan and organize behavior. The second postulate follows the first. When individuals have deficits in processing and integrating sensory inputs, deficits in planning and producing behavior occur that interfere with conceptual and motor learning. Finally, the postulate that guides intervention hypothesizes that the provision of opportunities for enhanced sensory intake, provided within the context of a meaningful activity and the planning and organizing of an adaptive behavior, will improve the ability of the central nervous system to process and integrate sensory inputs, and through this process, to enhance conceptual and motor learning. (Fisher, Murray and Bundy, 1991, p. 4).

The approach of sensory integration therapy is different from procedures used within the educational model for dealing with learning disorders. Educational approaches designed to alleviate learning disabilities (e.g. remedial reading) are believed to only address the symptoms of the disorder. The objective of sensory integration therapy is to modify the neurological dysfunction that interferes with learning. Although sensory integration therapy will not eliminate the underlying cause of the learning disability it will help to normalize the integration of stimuli (Ayres, 1972). Sensory integration therapy does not replace classroom instruction/remediation; it is used to supplement classroom learning.

Sensory integrative therapy can be used in occupational therapy to normalize the integration of the environmental stimulation and help produce a more appropriate adaptive behavior. This will help improve the child's ability to complete play, school and self-care activities more successfully.

Sensory integration occurs through convergence of sensory stimuli from many different modalities into the central nervous system. The sensory modalities on which the theory focuses are: vestibular, tactile, proprioceptive, auditory, olfactory, and visual systems (Ayres, 1972).

The Vestibular System

The vestibular system is phylogenetically one of the oldest sensory systems and is ontogenetically one of the first systems to myelinate in fetal life, at about 20 weeks. The systems which mature early phylogenetically appear to serve an important role in development (Ayres, 1972).

Anatomy and Physiology

The vestibular apparatus is a highly specialized sensory organ. It consists of the receptor organs of the inner ear, the vestibular tracts and nuclei, and the distant regions of the central nervous system that have connections by way of tract fibers. There are two different types of receptors in the vestibular system: the three semicircular canals (crista ampularous), and the otolith organs - the utricle and saccule of the vestibule (See Appendix A). The vestibular receptors are sensitive to head movement and the force of gravity. The motion of the head is detected by the semicircular canals and gravity is detected by the utricle (Ayres, 1972; Fischer, Murray & Bundy, 1991; Parker, 1980; West, 1985).

The signals enter the brain stem and terminate at different nerve cell groups called the vestibular nuclei: superior, lateral, medial and inferior nuclei. These cell groups also receive information from visual and somatic sensory end organs. Information is coordinated in these vestibular nuclei and a neural signal is then sent to the brain stem and thalamus (via ascending projections), cerebellum or the spinal cord (via descending projections) (Littell, 1990).

The signals that arrive in the cerebellum pass through the inferior cerebellar peduncle and arrive in the region of the vestibulocerebellum (Littell, 1990). The cerebellum influences muscle tone for posture and locomotion. It helps individuals to move smoothly, accurately and with proper timing (Barr, 1974).

Signals are also sent to descending pathways via the lateral vestibulospinal tract and the medial longitudinal fasciculus through the spinal cord. These tracts, through the spinal cord, regulate muscle tone throughout the body so that balance is maintained, it also provides change in muscle tone that is required to support the head in various positions during head movement (Barr, 1974; Littell, 1990; Parker, 1980).

Vestibular nuclei also control movements of the eyes. The pathway through the pons and midbrain carry ascending projections from vestibular nuclei to the neurons of the extraocular eye muscles - the abducens, trochlear, and oculomotor (Littell, 1990). These cranial nerve nuclei provide for synchronized scanning and tracking movements of the eyes and coordinated movement of the head, in an effort to maintain visual fixation on a distant object as the head moves in space (Barr, 1974; DeQuiros, 1978). The vestibular nuclei also send axons to the reticular formation which controls alertness of an individual (West, 1985).

Vestibular System Function

The vestibular system enables the organism to detect acceleration, deceleration and the earth's gravitational pull. Robbins (1977) stated that the vestibular system detects every movement of the head. The vestibular system assists the organism to know whether a given sensory input is associated with movement of the body or is a function of the external environment. The vestibular system has a strong influence on muscle tone; signals that are sent to the spinal cord from the vestibular system are responsible for muscle tone of the neck, limbs, and body muscles (Ayres, 1972, 1979; Parker, 1980; Shuer, Clark, & Azen, 1980; West, 1985).

Another function of the vestibular system is that of maintaining a stable visual field, and movement of the eyes. Signals from the vestibular system are sent to the eye and neck muscles to compensate for every movement of the head or body (Ayres, 1972; Parker, 1980; Shuer et al., 1980). The major functions of the vestibular system are control of eye movements, control of posture and conscious perception of space (DeQuiros, 1978; Polatajko, 1985).

The vestibular system organizes postural and equilibrium responses - automatic muscle contractions that keep the body balanced (Ayres, 1972; Ottenbacher, 1980). Responses elicited from the stimulation of the vestibular system facilitate muscles to evoke movements of the head, trunk, and limbs to compensate for postural sway (Fischer, Murray, & Bundy, 1991). The cerebellum, with input from the vestibular system, provides balance, orientation and coordination (Ayres, 1972; Shuer, Clark & Azen, 1980; West, 1985). The vestibular system also transmits input into the reticular activating system which serves to keep an individual alert (Ayres, 1972, 1979). The vestibular system also has connections to the autonomic nervous system centers (hypothalamus) in the brain. These centers control nausea, heart rate, breathing, vascular changes, salivation, gastrointestinal effects, perspiration, blood pressure, temperature regulation, sleep, and alertness (Ayres, 1972; Shuer et al., 1980; Weeks, 1979; West, 1985).

The vast connections of the vestibular system are important for postural mechanisms and eye tracking which are important for reading.

Relationship between the Vestibular System and the Visual System

The vestibular system is anatomically linked to the visual system. Getman (1981) emphasizes the interweaving of the visual system and the brain system for proper visual functioning. Ayres (1972) stated that nystagmus serves to illustrate the close connection between the vestibule and the extraocular muscles. Postrotary nystagmus is a reflexive eye jerk which occurs after spinning. Robbins (1977) stated that vestibular nuclei produce nystagmus which enables the eyes to follow moving objects or fixate on stationary ones while walking or turning. This relationship between the motion receptors and the extraocular muscles is critical to perceiving the correct relationship between the visual fields of an organism and the motion of the body. Reduced postrotary nystagmus is evidence of a poorly integrated vestibular system (Ayres, 1972).

The vestibuloocular reflex (VOR) is further evidence of the close connection between the vestibular system and the extraocular eye muscles. The vestibular system sends impulses to generate the VOR. The VOR comprises the reflex eye movement in the opposite direction of head movement to stabilize and compensate for vision while the head is moving. The pathway for the VOR involves the vestibular nuclei and eye motor neurons in the III (occulomotor), IV (abducens), and VI (trochlear) cranial nerve nuclei and the neuromuscular junctions in the extraocular muscles. It prevents head movements from disturbing retinal images (West, 1985). If the VOR is faulty during head movements, the image in the environment will move across the retina and produce a blurred image (Chee, 1978). As stated by DeQuiros (1976) "vestibular-occulomotor pathways control the skilled movements of the eyes and help to maintain the correct relationship between motion and space" (p. 41).

The vestibular nuclei contribute descending axons via the medial longitudinal fasciculus. The majority of fibers in the medial longitudinal fasciculus comes from the vestibular nuclei. The medial longitudinal fasciculus interconnects three pairs of motor nuclei cranial nerves III, IV, and VI which innervate the extraocular muscles. These extraocular muscles control coordinated movements of the eyes and maintain the visual field (West, 1985).

Testing for Vestibular Dysfunction

Testing for vestibular dysfunction can be accomplished in several ways: electronystagmography, caloric testing, and rotary testing. Electronystagmography is a method of recording nystagmus activity by detecting the electrical activity of the extraocular muscles with surface electrodes. It requires the use of sophisticated and expensive equipment, and consequently is not frequently used (Shuer et al., 1980; Thomas, 1985). The two most common and practical techniques are the caloric test and the rotation test (Shuer, Clark & Azen, 1980). The caloric test causes more discomfort than the rotation test; therefore the rotation test is used more frequently. In the caloric test, an individual is positioned in supine with the head flexed 60 degrees, the lateral or posterior canal is stimulated by cold water irrigated in the external auditory meatus (Heiniger & Randolph, 1981).

The most common form of testing used by occupational therapists is the rotation test developed by Ayres (1975). The Southern California Postrotary Nystagmus Test (SCPNT) "provides a standard procedure for measuring and comparing against normal expectations one of the more common types of nonpathological nystagmus" (Ayres, 1975, p. 1). Nystagmus is defined as an involuntary, rapid forward and backward motion of the eyes (fast forward and slow return). It results from stimulation of the horizontal semicircular canal of the vestibular system, optokinetic visual input, or a brain disorder (Ayres, 1975).

Morrison and Sublett (1983) examined the reliability of the postrotary deviation as measured by the SCPNT in learning disabled children. They found that a sample of 89 children with various learning disabilities demonstrated low SCPNT scores, but they also demonstrated more variability in scores than did a normal population. Due to the greater variation in children with learning disability reliability is somewhat lower.

The Southern California Postrotary Nystagmus Test is administered in the following way. The subject is asked to sit on a board that spins with legs crossed and head tilted forward to 30 degrees. The subject is spun clockwise 10 times in 20 seconds and stopped abruptly. The examiner records the maximal excursion and duration of nystagmus of the subject. The test is then repeated in the opposite direction after a 30 second resting phase. Scores are determined by normative data and standard deviation tables for males and females (Ayres, 1975).

Brain Processes in Reading

There are numerous brain processes that must work in concert for an individual to read accurately. Three crucial processes are 1) hemispheric specialization, 2) brain stem integration, and 3) interhemispheral integration.

Hemispheric Specialization

DeQuiros (1976) stated that hemispheric specialization is important for higher level circuits in the brain to function adequately. He also stated that slow progress in the development of specialization and in learning to read and write are characteristics of many students with learning disabilities.

If the brain has developed hemispheric specialization automatic motor acts (such as walking) are controlled by one hemisphere while the other hemisphere develops specialization in the control of communication. If this specialization is late in being established then the circuits of the brain that should be used for higher functions such as reading, writing, speech and other symbolic processes are recruited. Higher level circuits then become overloaded with body information while correcting lower circuit deficiencies. Therefore higher level circuits are not free to execute their appropriate functions (DeQuiros, 1976). Some children with hemispheric dysfunction may show subcortical deficits such as poor processing of vestibular-proprioceptive information. Sensory integrative procedures to enhance vestibular-proprioceptive function may be appropriate to affect these subcortical deficits and therefore help improve skills such as reading (Fisher, Murray, & Bundy, 1991).

Brain Stem Integration

It is believed that visual processing occurs initially in the brain stem (Ayres, 1972a). Ayres (1979) has stated that for higher functioning capabilities, the brain stem must be properly integrated. The higher levels (complex organization) of the brain remain dependent upon the lower structures (simple sensorimotor functions) (Ayres, 1968). Fischbach (1992) states that sensory systems are arranged in a hierarchial manner. He also states that information does not travel along a single pathway, different features are processed in parallel pathways to higher centers. If the brain stem is not receiving adequate information about the external environment, such as proper information from the vestibular system, then this will detrimentally effect the functions of the higher centers in the brain. Therefore, it would be difficult for an individual with learning disability and vestibular dysfunction to learn to read (higher level skill) properly while his brain is not functioning on a stable foundation.

In relationship to reading disabilities, this theory suggests that reading requires more than highly integrated activity in a certain areas of the cortex. Reading is dependent upon normal function in other cortical and subcortical structures, including the brain stem (Ayres, 1968).

Interhemispheral Integration

Interhemispheral integration is essential to reading for two reasons. The two halves of the visual field of each eye go to the two different hemispheres of the brain, thus interhemispheral integration is required to relate the two halves. (Ayres, 1968, 1972).

Associating language with the visual stimuli of reading requires brain stem interhemispheral integration (Ayres, 1972). Vestibular stimulation is known to increase bilateral integration, thus it might be assumed that reading ability may also be improved.

Normalizing sensory input to the vestibular system may have an effect on improving reading skills in children with learning disability as will be discussed below.

The Physiological Effects of Vestibular Stimulation on Reading

Vestibular stimulation influences the body in the following ways; in the child with dysfunction, synapses which normally are formulated as a result of vestibular input are activated. Muscle tone is increased and the enhanced facilatory effect on the muscle fibers prepares the nervous system for easier activation of the neurons supplying the skeletal muscles in ensuing activity.

The extraocular muscles are a type of skeletal muscle and are facilitated especially through the connections of the vestibular nuclei with cranial nerve nuclei III, IV, and VI over the medial longitudinal fasciculus.

Vestibular System Related to Reading Ability

As was described previously there is a neurological connection between the vestibular system and the extraocular muscles of the eyes. Knowing that the vestibular system has influence over the eye muscles, it has been the subject of research with children with learning disabilities.

Levinson (1989) stated "the cerebellar-vestibular system was reasoned to act as a guiding system directing the eyes to fixate, sequentially track and process letters, words, and word-sequences in space and time so that they might be gnostically or cortically understood" (Levinson, 1989, p. 36).

Ottenbacher (1979) examined children with learning disability who had hyporesponsive nystagmus and assessed their visual fixation capabilities. He was responding to the fact that the vestibular system is intimately involved in controlling eye movements, that eye movement control is important in academic skills such as reading, and that these eye movements are often abnormal in children with learning disabilities. Ottenbacher's conclusion was that the children with depressed postrotary nystagmus were deficient in oculomotor fixation.

Frank and Levinson (1973) evaluated 115 dyslexic children and found evidence of a cerebellar-vestibular dysfunction in 112 of these children. They proposed the following hypothesis regarding cerebellar-vestibular circuits role in dyslexia.

1. The cerebellar-vestibular circuits provide a harmonious, well integrated, and stable motor background for visual perception.

2. This motor background or motor Gestalt is nothing more than the subliminal, automatic, integrated motor activity of the eye muscles, head,and neck so that ocular fixation and sequential scanning of letters and words can take place.

3. In the presence of a cerebellar-vestibular dysfunction and subclinical nystagmus, ocular fixation and sequential scanning of letters and words are disordered and letter and word scrambling results.

4. This scrambling and resulting dysmetric visual perception lead to deficient comprehension or dyslexia. (Frank & Levinson, 1973, p. 692-693).

Sobotowicz and Evans (1982) stated that damage to cerebellar-vestibular system causes reduced nystagmus, increased ocular fixation and decreased sequential scanning of visual stimuli. They stated that the scrambling of visual input cause reading disorders at the perceptual level.

Walsh (1974) stated that subjects with ocular motor deficits and poor reading behaviors often exhibit poor ocular muscle coordination (the vestibular system has been related to the ocular muscles and adequate functioning of these muscles is needed for reading).

Gregg (1976) studied the effects of vestibular stimulation on enhancing visual pursuit in neonates. She found that after infants had been exposed to vestibular stimulation they engaged in significantly more efficient visual pursuit than infants who had not been moved.

Levinson (1988) studied 4000 patients with learning disability (children, adolescents and adults). He concluded that "data clearly indicate that ocular fixation, tracking and orientation errors (and underlying mechanisms) as well as related instability of memory consistent with cerebellar-vestibular dysfunctioning characterize the reading disorders in this sample" (Levinson, 1988, p. 996).

Vestibular System's Influence on Reading

Ayres (1972) has stated that "considerable opportunity exists for the vestibular system to exercise influence over all other ongoing sensory experiences" (p. 57). The vestibular system has extensive influence on motor output. Nystagmus illustrates the connection between the vestibular system and the extraocular muscles (Ayres, 1972).

DeQuiros (1976) studied 63 children with learning disabilities and 52 had abnormal vestibular responses. He stated that one of the primary vestibular disorders that characterized these children was motor problems in reference to reading and writing. DeQuiros believed that the importance of vestibular input in reading and writing is that of the vestibular-oculomotor pathways. The vestibulo-oculomotor pathways control the skilled movements of the eyes (through the extraocular muscles) which are essential for reading (DeQuiros, 1976).

Levinson (1989) attempted to measure the ocular fixation and sequential scanning dysfunction that may be responsible for visual reading symptoms which characterize dyslexia or learning disability. He devised an optokinetically based tracking method and subjected 70 cerebellar-vestibular dysfunctioning subjects with learning disabilities and 70 controls to testing using the optokinetic tracking method. He found that the learning disabled subjects demonstrated significantly decreased fixation, tracking and visual-span scores in comparison to the controls.

Reading requires that the brain process detailed sensations and engage in accurate motor and mental responses. The visual system must process small differences between letters and numbers. For the brain to do this, all parts of the brain that deal with language and all parts that deal with visual perception have to function adequately together. None of these brain functions can work well if the brain cannot receive and process sensations from movement and gravity. If a child has a vestibular disorder many of the sensory motor patterns in the brain will be disorganized and the child will have difficulty knowing the meaning of a printed word (Ayres, 1979).

Vestibular Dysfunction and Learning Disabilities

Vestibular dysfunction has been linked to other disabilities as well as learning disabilities. Vestibular stimulation, either separately or in combination with other sensory integrative therapy, has been reported to effect improvements in children with various problems (Ayres, 1972a).

A number of studies using vestibular stimulation have been conducted to improve disabilities. Bonadonna (1981) found that three severely mentally retarded persons who were exposed to a program of vestibular stimulation displayed reduction in both frequency and duration of rocking behavior. Baker-Nobles and Bink (1974) subjected three blind adults to six months of vestibular stimulation and found improvements in mobility, activities of daily living, handwriting, and behavior.

Bhatara, Clark and Arnold (1978) examined the effects of semicircular canal simulation on decreasing hyperkinetic behavior in a five year old boy. Their results indicated that improvement in behavior occurred. Kantner, Kantner and Clark (1982) observed the effects of vestibular stimulation on language ability in mentally retarded children. Results indicated that vestibular stimulation played a supportive role in improving general communication skills in these children.

Clark, Kreutzberg and Chee (1977) examined preambulatory infants exposed to vestibular stimulation. The data confirmed that exposure to vestibular stimulation accelerated gross motor development. Chee, Kreutzberg and Clark (1978) studied the effects of vestibular stimulation on preambulatory children with cerebral palsy. Their results suggested that vestibular stimulation produced more appropriate interaction between the vestibular system and the visual system. "With the development of more appropriate vestibuloocular control, and hence a more stable retinal image during head movements, the children with cerebral palsy are more able to interact successfully with their environment" (Chee, Kreutzberg & Clark, 1978, p. 1075).

Ottenbacher et al (1979) sought to strengthen the claim that duration of postrotary nystagmus of children with learning disabilities was affected by therapeutic intervention. He examined the effect of sensory integration therapy on the duration of nystagmus on two groups of learning disabled children, one short term therapy (less than 6 months) and one long term therapy (greater than 6 months). He found that children with reduced nystagmus exhibited increase in duration and these changes were more apparent following long therapy than short therapy.

Kantner, Clark, Allen and Chase (1976) studied the effects of vestibular stimulation on motor skills in children with Down's Syndrome versus normal children. They found that after ten days of vestibular stimulation the children with Down's Syndrome reduced hyperreactive postrotary nystagmus and improved motor performance.

The majority of research on the vestibular system has been conducted with children with learning disabilities. DeQuiros (1976) and Ayres (1972, 1972a, 1978, 1979) have found that many children with vestibular dysfunction also exhibit learning disabilities. Children with learning disabilities exhibit a wide variety of associated problems including reading difficulties.

Chiarenza (1990) studied children with learning disabilities and reading disorders and found that children with reading disorders exhibited poorer quality of movement, speed, fluidity and adequacy than normal children.

DeQuiros (1976) identified characteristics at the primary school level of children with vestibular dysfunction: "(1) caloric hyporeflexia, (2) restlessness (3) motor problems in reference to reading and writing, and (4) loss of interest in school learning" (1976, p. 51). DeQuiros (1976) summarized his research by stating, "Vestibular disorders can produce learning disabilities associated with motor skills, the acquisition of language and the development of normal competencies in reading and writing" (p. 55). He concluded that vestibular disorders and associated postural disturbances can produce learning disabilities and that children with such disorders make up a large part of the learning disabled population (De Quiros, 1976).

Ayres (1978) conducted research with children with learning disabilities who exhibited vestibular dysfunction (measured by postrotary nystagmus) and found that sensory integrative therapy could be effective in facilitating academic achievement among children with hyporeactive nystagmus. She also suggested that since therapy to enhance vestibular input processing changed academic achievement, a relationship exists between the vestibular disorder and academic learning (Ayres, 1978).

Polatajko (1985) studied vestibular dysfunction in children with learning disabilities. Her research did not support the claim that learning disabled children exhibit vestibular dysfunction. She studied 40 children with learning disabilities and a control group of 40 normal children and found "no support for the notion that learning disabled children suffer from vestibular dysfunction" (p. 290). She explained that the difference in findings could be attributed to difference in methodology and interpretation of the SCPNT and also selection of subjects. She did not select subjects with perceptual-motor problems or sensory integrative deficits, only with learning disabilities. Wiss (1989) stated that Polatajko did not assess the effect of the problem of integration of vestibular stimuli with other sensory input that children with learning disabilities may have.

Remediating Reading Difficulties with Vestibular Stimulation

The vestibular system has influence over the brain systems that control reading, and vestibular dysfunction has been shown to affect reading. It has been hypothesized that stimulation of a dysfunctional vestibular system will help to normalize sensory input and help improve reading skills.

Various studies to determine the effects of vestibular stimulation have been conducted. Ayres performed two such studies on children with learning disability. In the first study children with auditory-language deficits received therapy which consisted of considerable vestibular stimulation. These children gained significantly more on reading scores than did a matched control group (Ayres, 1972a). In the second study, children with learning disability and depressed nystagmus, who received therapy to improve vestibular input processing, greatly enhanced their academic achievement which included reading (Ayres, 1978).

In addition, Angelo (1980) found that a group of low achieving college students, who participated in sensory integrative therapy which incorporated vestibular stimulation, resulted in their reading skills improving significantly. Angelo concluded, "Vestibular stimulation is significant to the control of saccadic and conjugate eye movement, which is essential for visual fixation and scanning movements of the eyes. Fixation and smooth scanning are necessary for reading" (Angelo, 1980, p. 672).

Wilson and Ewen (1985) engaged college students with reading difficulty and vestibular system dysfunction in 14-16 weeks of vestibular stimulation.

Their hypothesis proposed that treatment intervention with vestibular stimulation incorporated would produce changes in reading comprehension, reading rate, postrotary nystagmus, and standing balance. Their results showed significant changes in postrotary nystagmus, standing balance and reading comprehension and provided evidence that vestibular stimulation is an effective mode of treatment for college students with reading problems and vestibular system dysfunction.

Werry, Scaletti and Mills (1990) exposed children with learning problems to nine months of sensory integration treatment (which included vestibular stimulation) and found that after nine months all groups had improved significantly on word recognition, reading, vocabulary and motor performance.

Grimwood and Rutherford (1980) studied the effects of sensory integration therapy (which included vestibular stimulation) on a group of children in grade one who were found to be at risk for reading failure. After subjecting the experimental group to two 30 minutes sessions per week for 24 weeks they performed significantly higher on reading ability than the control group. The experimental group maintained these gains over a two year period without intervention.

White (1979) studied the effects of a program of sensory integration treatment (which included vestibular stimulation) on first grade children who were at risk for reading failure. She examined the effect of sensory integration treatment on an experimental group who received individualized sensory integrative treatment for two, 30 minute sessions per week. Activities that were provided enhanced the vestibular, proprioceptive, and tactile function of the subjects. These children showed a significant difference between the experimental and control groups on measures of reading at the completion of year one (after six months of treatment), one and two years later without being given further intervention the experimental group continued to show higher scores than the control group.

Evidence exists to verify that vestibular stimulation can be helpful in improving reading skills in children. It is hoped that this study will provide further evidence for use of vestibular stimulation in occupational therapy for the treatment of children with learning disability.

Summary

Literature has shown that there is a neurological connection between the vestibular system and movements of the eyes. Research has been completed which suggests that individuals with a dysfunctional vestibular system associated with hypoactivity may have difficulty with reading ability. The literature suggests that use of sensory integrative techniques such as vestibular stimulation can be a powerful tool for remediation of reading difficulties.

Use of the sensory integrative technique of vestibular stimulation is important in occupational therapy. The goal of occupational therapy is to improve function and assist individuals to be as independent as possible in their daily living skills. Reading is a very important daily living skill, not only for children in the classroom, but throughout life. Occupational therapy in combination with classroom learning can help a child with learning disability to become more independent.

Not all of the studies reviewed reported positive results with the use of vestibular stimulation for improving academic skills, but the majority of research found favored the use of vestibular stimulation. Based on the research reviewed there is a need for information regarding the use of vestibular stimulation as a technique for improving reading recognition, word attack, and reading comprehension skills.

CHAPTER THREE

RESEARCH PROCEDURES AND METHODOLOGY

The purpose of this study was to determine if a program of vestibular stimulation would increase the reading recognition, comprehension, and word attack skills of children with learning disability. The children used English as their first language and demonstrated reading difficulties and vestibular system dysfunction.

The questions generated for this study were:

1. Does vestibular stimulation increase reading comprehension in children with learning disabilities and accompanying vestibular dysfunction?
2. Does vestibular stimulation increase reading recognition in children with learning disabilities and accompanying vestibular dysfunction?
3. Does vestibular stimulation increase word attack skills in children with learning disabilities and accompanying vestibular dysfunction?

Design

A single subject ABA design was used for this study. Data were collected by pretest, continuous documentation, and posttest. Subjects served as their own controls. This provided the researcher with the most equivalent control group possible (Oyster, 1987). The use of single subject design is most like clinical practice in occupational therapy when individualized therapy is administered. It allowed the researcher to more closely monitor the subjects.

The independent variable was vestibular stimulation, the dependent variables were reading skills of recognition, comprehension, and word attack.

Subjects

The subjects in this study were three students enrolled at Madison Elementary school. One subject dropped out during the first four weeks of intervention, thus results are not included in the research report.

The subjects were chosen on the basis of the following criteria: children who demonstrated reading difficulties, whose first language is English, whose scores were below age level on the Woodcock-Johnson Psychoeducational Battery in the areas of reading recognition, word attack, and passage comprehension, and whose scores on the Southern California Postrotary Nystagmus Test demonstrated vestibular dysfunction. Subjects were screened for seizure disorders, uncorrected vision and nausea resulting from spinning. Those who exhibited any of the latter were excluded from the study. Subject's parents were asked to sign a consent form for their child's participation in the study (See Appendix C).

Approximately 10 students enrolled in a learning handicapped class were initially screened for participation in the study. These students were screened for vestibular dysfunction using the Southern California Postrotary Nystagmus Test. The test was administered by the researcher, who was trained by an occupational therapist certified in the administration of the Southern California Postrotary Nystagmus Test.

The subject's parents were asked to sign a consent form before the screening. Subjects who had visual difficulties were identified. If during the testing a subject showed signs of nausea, pallor, distress or threat, testing was stopped immediately.

Based on the criteria of the Southern California Postrotary Nystagmus Test (Ayres, 1975) and data reported by Heinger (1985), it was determined that subjects with a total (left and right spinning reactions) postrotary nystagmus duration below 20 seconds be included in the study. Heiniger and Randolph (1985) have stated that "any duration less than 9 seconds for girls and 10 seconds for boys is significant" (p. 75) This was information taken from a lecture given by Ayres in 1976. According to the Southern California Postrotary Nystagmus Test (1975) a score of 10 to 30 seconds for boys is within normal limits. Therefore, subjects whom exhibited a combined score of 20 seconds or less were included in the study and determined to have an underactive vestibular system.

Data Collection Techniques

Each of the subjects received identical evaluation procedures so that a baseline for each could be acquired. The subjects were tested with the Southern California Postrotary Nystagmus Test (SCPNT) and the Woodcock-Johnson Psycho-Educational Battery. The SCPNT tests for vestibular dysfunction. The SCPNT "provides a standard procedure for measuring and comparing against normal expectations one of the more common types of nonpathological nystagmus" (Ayres, 1975, p. 1). The SCPNT scores from the initial screening were used as the pretest scores for the subjects who were determined to be appropriate for the study.

The Woodcock-Johnson battery is a wide range comprehensive set of tests for measuring cognitive ability, achievement and interest. It is individually administered and has norms for the preschool to geriatric level (Woodcock-Johnson, 1977). Part two consists of 10 subtests which measure reading, math, written language, science, social studies, and humanities. Only the reading test was utilized in this study. There are separate norms for each section of the test. The reading test assessed letter-word identification, word attack, and passage comprehension. The three subjects were pretested for reading levels using the Woodcock-Johnson Psychoeducational Battery.

After completion of the intervention period the subjects were posttested with the Southern California Postrotary Nystagmus Test and the Woodcock-Johnson Psychoeducational Battery.

Intervention Techniques

After the subjects were determined to be appropriate for the study and pretested using the above evaluations, the subjects received 20 minute sessions of vestibular stimulation three times per week. The subjects were asked to leave their classes for that time to participate in the study. The vestibular stimulation intervention lasted for a total of eight weeks (the duration of the spring school session). The stimulation was provided in a variety of ways to ensure that all aspects of the vestibular system were adequately stimulated.

The first type of vestibular intervention consisted of a spinning activity. The subject was asked to lay in a carpeted barrel. Once the subject was securely in the barrel he was rolled ten times to the right and ten times to the left.

For the next type of vestibular stimulation the subject was asked to lie in the prone position on a scooter board. Then the subject was accelerated down a ramp with a 35 degree angle of incline, 10 times. The above two activities stimulated the semicircular canals.

The subject was also asked to jump vertically 20 times on a small trampoline while holding onto the hands of the examiner. As the third stimulus this provided stimulation to the gravitational portion of the vestibular system, the saccule.

Throughout the eight weeks of intervention each set of intervention activities were documented. The comments and observable behavior were recorded by the examiner at each treatment session. This helped the examiner to note changes in attitudes, behavior and moods of the subjects and any observable difference in reactions to the equipment (fear, pleasure, etc.).

CHAPTER FOUR

Data and Results

This study utilized a single subject (ABA) design. Identical screening and pretests were given to form a baseline for each subject. The treatment intervention consisted of eight weeks of vestibular stimulation for 20 to 30 minutes three times per week. Continuous documentation of subject's observable behavior was recorded. At the end of eight weeks the subjects were posttested to determine the effects of intervention period. The data were analyzed and are described using percentage increase or decrease and descriptions of observable changes in subjects.

Only three subjects of a projected sample of five were obtained for this study who met the criteria for inclusion. The results are based on the two remaining students who participated in the entire study.

The data are presented in the following manner: 1) frequency of contact, 2) objective data and 3) observable behaviors and comments from subjects.

Frequency of Contact

The two students were seen by the researcher for the duration of one school session which consisted of eight weeks. The researcher had contact with the subjects three times per week for approximately 20 - 30 minutes each session. The students were asked to leave regular class, accompany the researcher to the intervention area and were seen at the end of their school day for the last 30 minutes before they went home.

Data Presentation

Subject 1 Demographics

Name - J.V.

Age - 12 years 5 months

Grade level - 5th grade

Sex - Male

Living situation - Lives at home with parents

Ethnic Origin - Hispanic

Life Roles - Student, son, brother, friend

<u>Objective Data</u>

On the Southern California Postrotary Nystagmus Test, J.V. showed a score of 11 seconds on the pretest when rotated to the left, and a posttest score of 11 seconds. He showed a score of 7 seconds when rotated to the right on the pretest and 14 seconds on the posttest. The total scores (combined scores of rotation to the left and right) showed 18 seconds on the pretest and 25 seconds on the posttest. (See Table 1 and Graph 1).

Scores were obtained from the Woodcock-Johnson Test in the areas of letter-word identification, passage comprehension, word attack, and reading vocabulary. J.V.'s score on the Woodcock-Johnson Test in the area of letter-word identification revealed 460 on the pretest and 466 on the posttest. His score on passage comprehension revealed 452 on the pretest and 466 on the posttest. In the area of word attack, he scored 475 on the pretest and 477 on the posttest. Reading vocabulary score showed 460 on the pretest and 467 on the posttest. (See Table 2 and Graph 2).

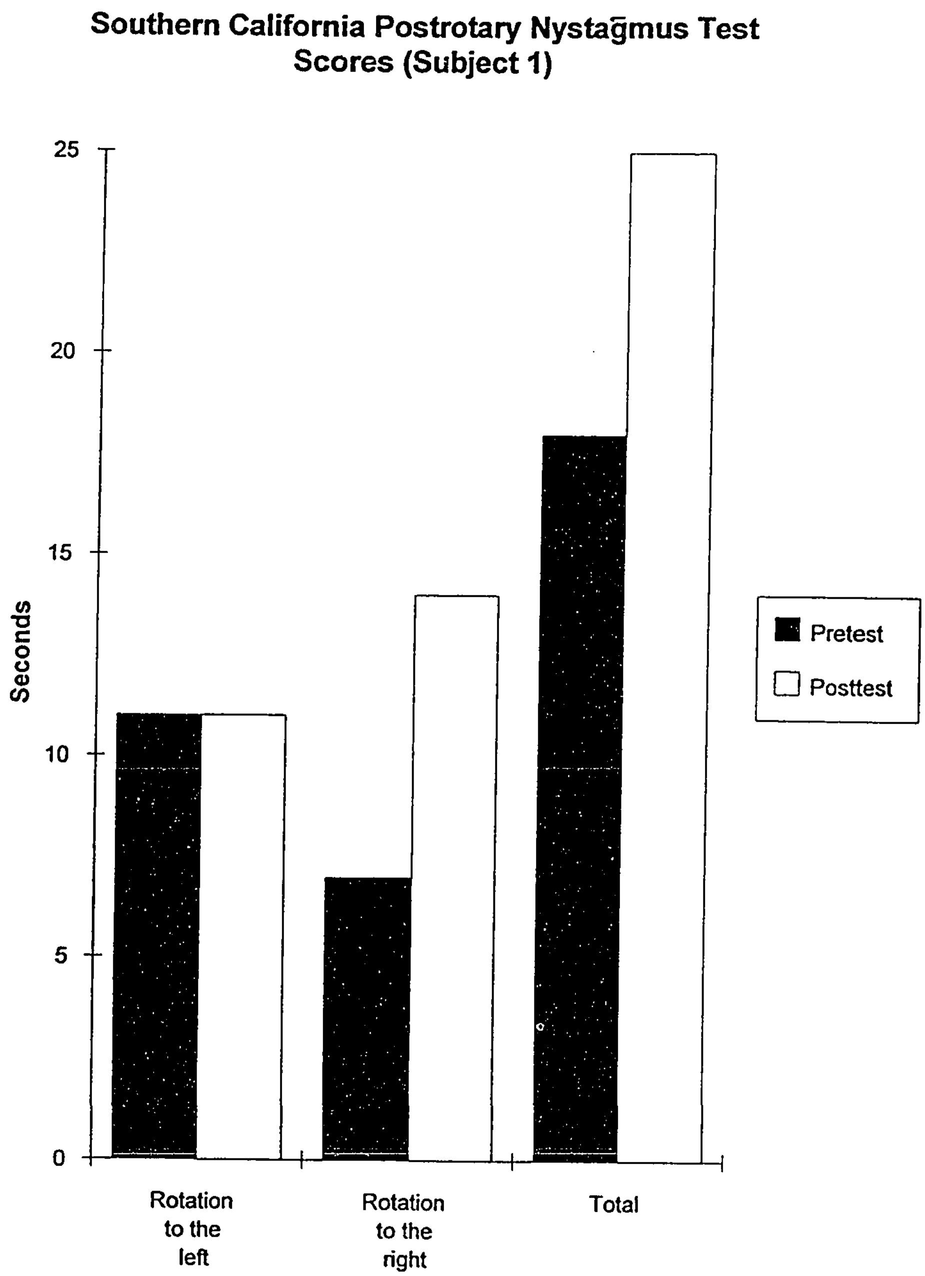
Table 1
Southern California Postrotary Nystagmus Test Scores

	Pretest	Posttest
Rotation to the Left (secs)	11	11
Rotation to the Right (secs)	7	14
Total (secs)	18	25

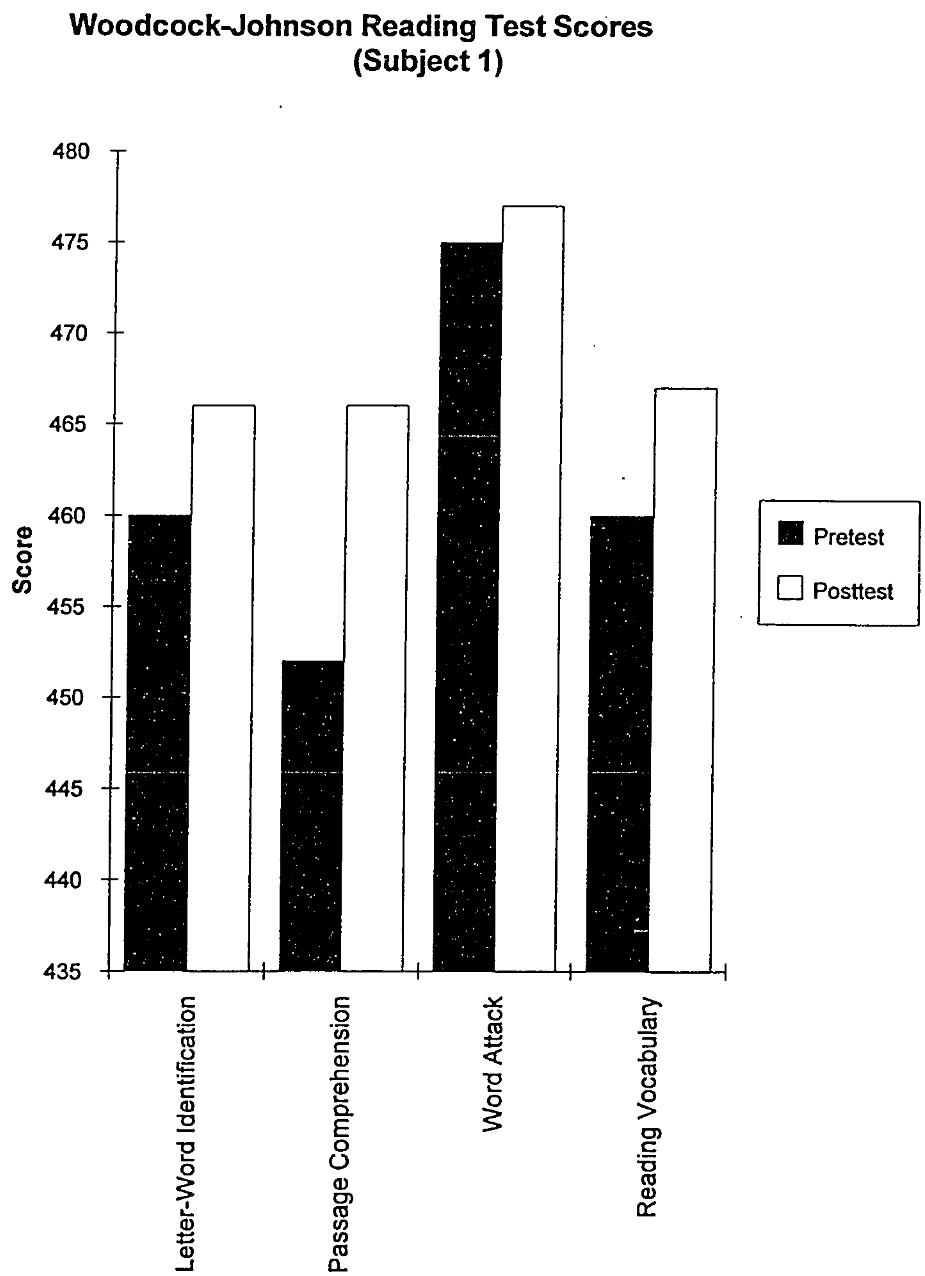
Table 2
Woodcock-Johnson Reading Test Scores

	Pretest	Posttest
Letter-Word Identification	460	466
Passage Comprehension	452	466
Word Attack	475	477
Reading Vocabulary	460	467

Graph 1


Southern California Postrotary Nystagmus Test Scores (Subject 1)
25
20
15
10
5
0
Seconds
Rotation to the left
Rotation to the right
Total
Pretest
Posttest

Graph 2


Woodcock-Johnson Reading Test Scores
(Subject 1)
480
475
470
465
460
455
450
445
440
435
Score
Pretest
Posttest
Letter-Word Identification
Passage Comprehension
Word Attack
Reading Vocabulary

J.V.'s grade equivalent on the Woodcock-Johnson test in the area of letter-word identification showed 2.3 on the pretest and 2.6 on the posttest. In passage comprehension his grade equivalent was grade 1.6 on the pretest and 2.2 on the posttest, grade equivalent in the area of word attack was grade 2.0 on the pretest and grade 2.1 on the posttest. Grade equivalent in reading vocabulary changed from grade 1.7 to 2.0. (See Table 3 and Graph 3).

J.V.'s age equivalent on the Woodcock-Johnson test in letter-word identification changed from 7-10 years on the pretest to 8-1 years on the posttest. His age equivalent in passage comprehension changed from 7-2 years to 7-8 years. In word attack skills, age equivalent revealed 7-7 years on pretest and 7-9 years on posttest. Reading vocabulary age equivalent showed 7-1 years on pretest and 7-5 on the posttest. (See Table 4 and Graph 4).

Table 3

Woodcock-Johnson Reading Test Grade Equivalents

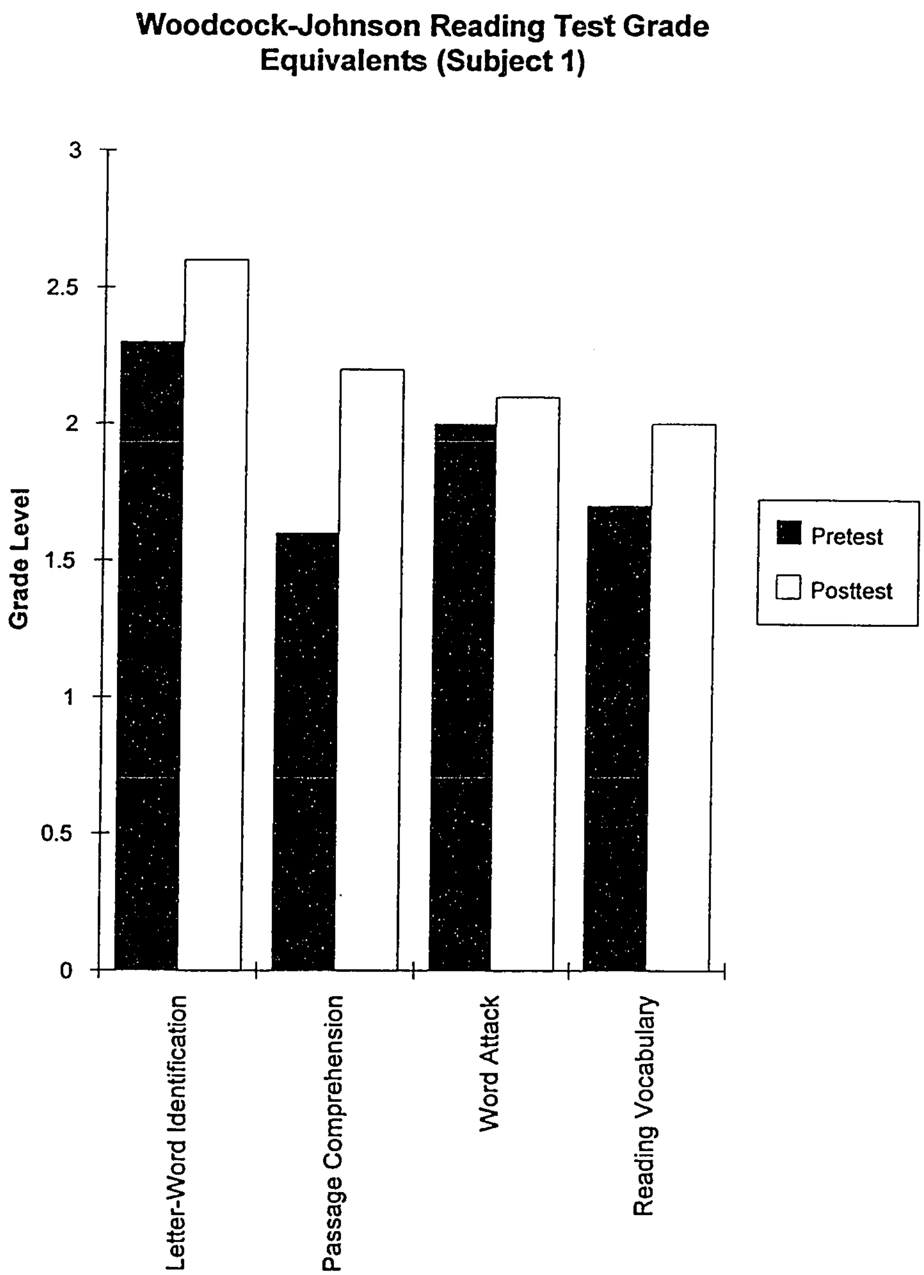
	Pretest	Posttest
Letter-Word Identification	2.3	2.6
Passage Comprehension	1.6	2.2
Word Attack	2.0	2.1
Reading Vocabulary	1.7	2.0

Table 4

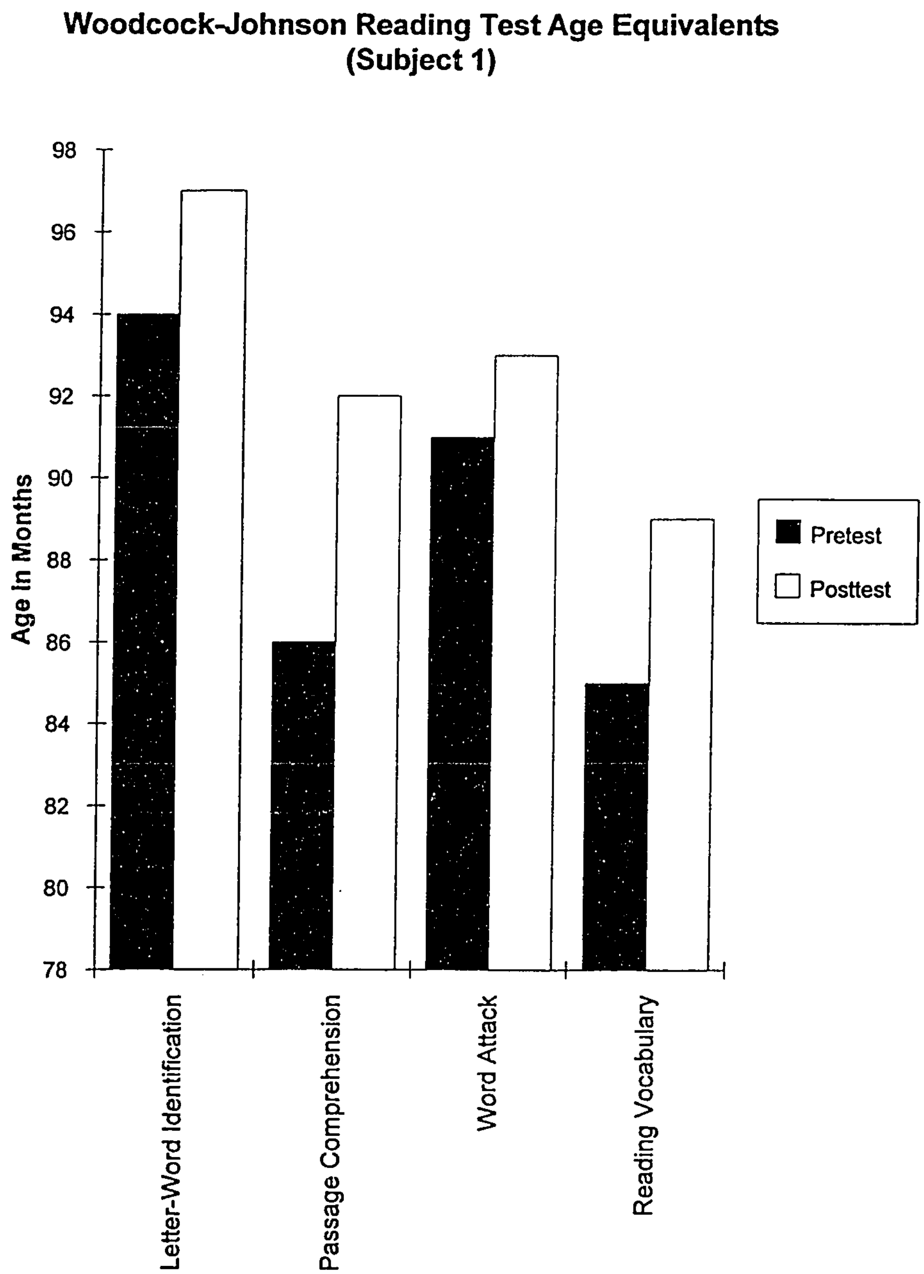
Woodcock-Johnson Reading Test Age Equivalents

	Pretest	Posttest
Letter-Word Identification	7-10	8-1
Passage Comprehension	7-2	7-8
Word Attack	7-7	7-9
Reading Vocabulary	7-1	7-5

Graph 3


Woodcock-Johnson Reading Test Grade Equivalents (Subject 1)
3
2.5
2
1.5
1
0.5
0
Grade Level
Pretest
Posttest
Letter-Word Identification
Passage Comprehension
Word Attack
Reading Vocabulary

Graph 4


Woodcock-Johnson Reading Test Age Equivalents
(Subject 1)
Age in Months
98
96
94
92
90
88
86
84
82
80
78
Letter-Word Identification
Passage Comprehension
Word Attack
Reading Vocabulary
Pretest
Posttest

Observable Behaviors and Comments from Subject 1

Pretest. When given the Southern California Postrotary Nystagmus Test, J.V. exhibited some reluctance to complete the postrotary nystagmus test, but when he was reassured and the test was again described to him he was willing to participate. He expressed "how fun" the Southern California Postrotary Nystagmus Test was after he had taken it. He was able to maintain his balance while turning, he expressed no feelings of dizziness, nausea, alarm or threat during the testing. He did express mild experience of vertigo and definite pleasure from rotation.

Intervention Period. Initially during the intervention period as in the pretest, J.V. was somewhat apprehensive about the treatment activities. He would engage in the activities with no difficulty after they were explained to him and he was reassured that he would be safe. He completed the activities and stated that he liked the scooterboard activity best. He stated that he felt dizzy after he had completed the barrel rolling. This was the activity that he was most apprehensive about but liked once it was completed. After approximately 3-4 sessions, J.V. appeared to enjoy the activities more. He began to say "Wheeee!" when going down the ramp on the scooterboard. He began to jump higher on the trampoline, asking to do it all by himself without anyone present. He no longer expressed apprehension about the barrel activity and really enjoyed each treatment session.

Posttest. He showed no apprehension when asked to take the posttest to measure his vestibular function. He was very cooperative and enjoyed completing the test. On the posttest, he maintained his balance while turning, held his head steady, had a mild experience of vertigo, no dizziness, nausea, alarm or threat was noted, and he experienced definite pleasure from rotation. When completing the Woodcock-Johnson posttest, J.V. exhibited some reversals of letters when reading words. For example when reading nonsense words such as "ib", he would read "bi".

Subject 2 Demographics

Name - J.H.

Age - 9 years

Grade level - 2nd grade

Sex - Male

Living Situation - Lives at home with parents

Ethnic Origin - Hispanic

Life Roles - Student, son, friend

Objective Data

Results of the Southern California Postrotary Nystagmus Test showed a duration of 5 seconds when rotated to the left on the pretest and a duration of 10 seconds on the posttest. When rotated to the right J.H. showed a duration of 5 seconds on the pretest and 10 on the posttest. The combined scores showed a duration of 10 seconds on the pretest and 20 on the posttest. (See Table 5, Graph 5).

Scores on the Woodcock-Johnson test were documented in the areas of: letter-word identification, passage comprehension, word attack, and reading vocabulary. In the area of letter-word identification, J.H. showed a score of 457 on the pretest and 463 on the posttest. Passage comprehension pretest score showed 461 and posttest score showed 470. In the area of word attack pretest score changed from 477 to 484 on posttest. Reading vocabulary showed a score of 467 on the pretest and a score of 477 on the posttest. (See Table 6 and Graph 6).

Woodcock-Johnson grade equivalents in the area of letter-word identification showed grade 2.1 on the pretest and 2.4 on the posttest. Passage comprehension grade equivalent exhibited a pretest score of grade 2.0 and a posttest score of 2.4. Word attack grade equivalents showed a score of grade 2.1 on the pretest and grade 2.6 on the posttest. Grade equivalent in the area of reading vocabulary changed from grade 2.0 on the pretest to 2.5 on the posttest. (See Table 7 and Graph 7).

Table 5

Southern California Postrotary Nystagmus Test Scores

	Pretest	Posttest
Rotation to the Left (secs)	5	10
Rotation to the Right (secs)	5	10
Total (secs)	10	20

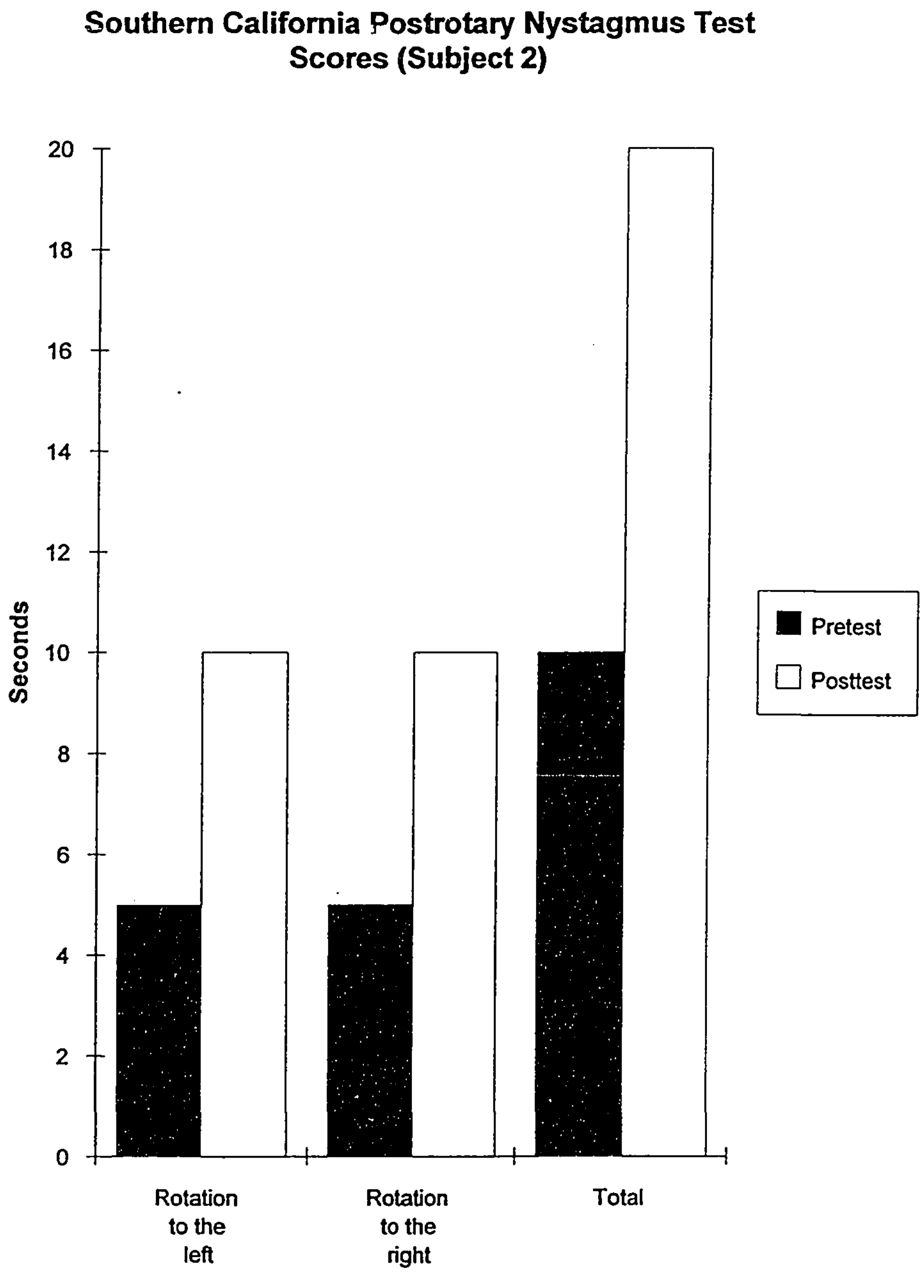
Table 6

Woodcock-Johnson Reading Test Scores

	Pretest	Posttest
Letter-Word Identification	457	463
Passage Comprehension	461	470
Word Attack	477	484
Reading Vocabulary	467	477

Age equivalents on the Woodcock-Johnson test in letter-word identification revealed a score of 7-8 years on the pretest and 7-11 years on the posttest. Passage comprehension age equivalent changed from a pretest score of 7-6 years to 7-10 years. Age equivalents in word attack skills exhibited 7-9 years on the pretest and 8-2 years on the posttest. Reading vocabulary age equivalent showed a score of 7-5 years on the pretest and a score of 8-1 years on the posttest. (See Table 8 and Graph 8).

Graph 5


Southern California Postrotary Nystagmus Test
Scores (Subject 2)
Seconds
20
18
16
14
12
10
8
6
4
2
0
Rotation
to the
left
Rotation
to the
right
Total
Pretest
Posttest

Graph 6

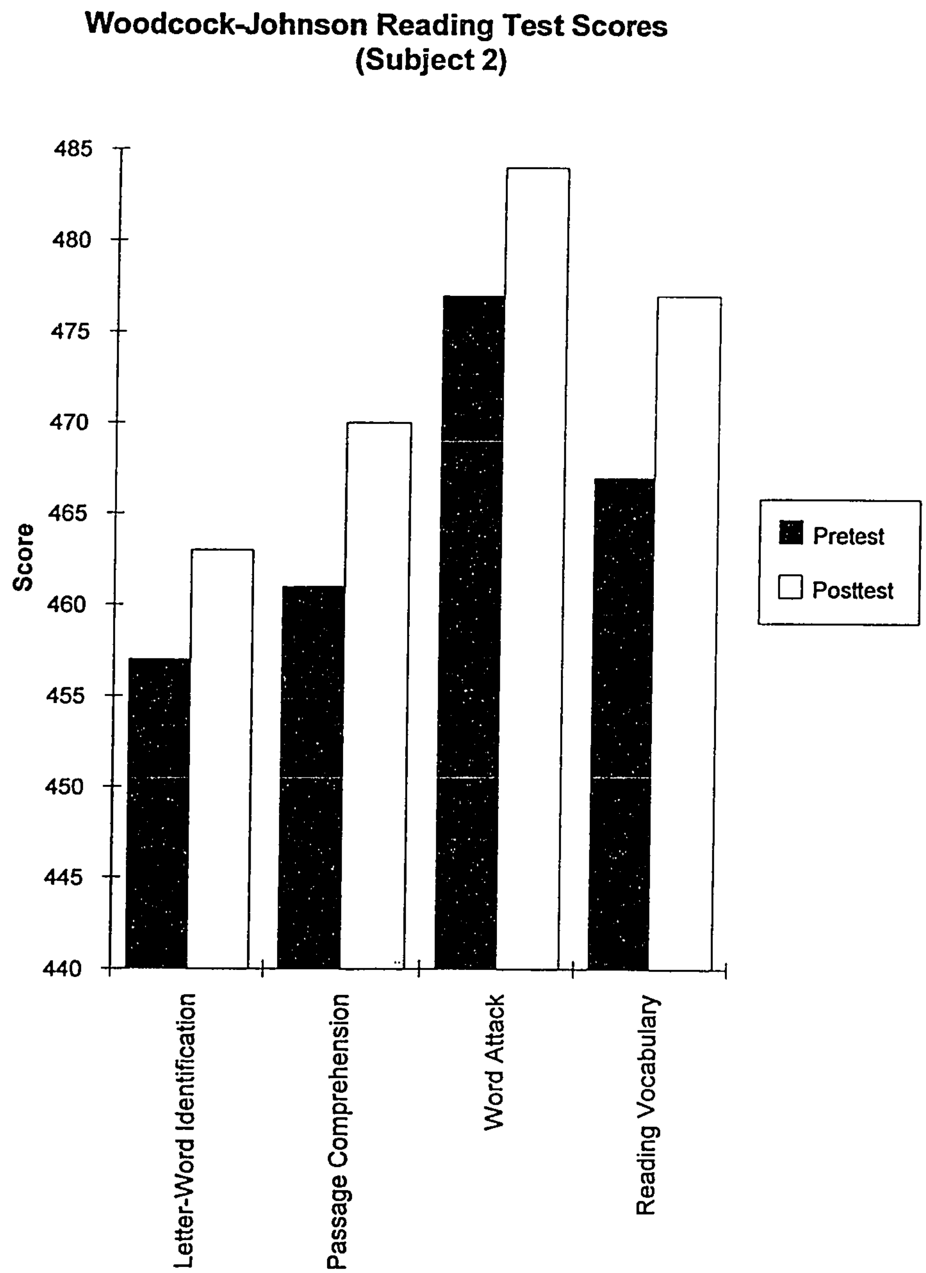

Woodcock-Johnson Reading Test Scores
(Subject 2)
Score
485
480
475
470
465
460
455
450
445
440
Letter-Word Identification
Passage Comprehension
Word Attack
Reading Vocabulary
Pretest
Posttest

Table 7

Woodcock-Johnson Reading Test Grade Equivalents

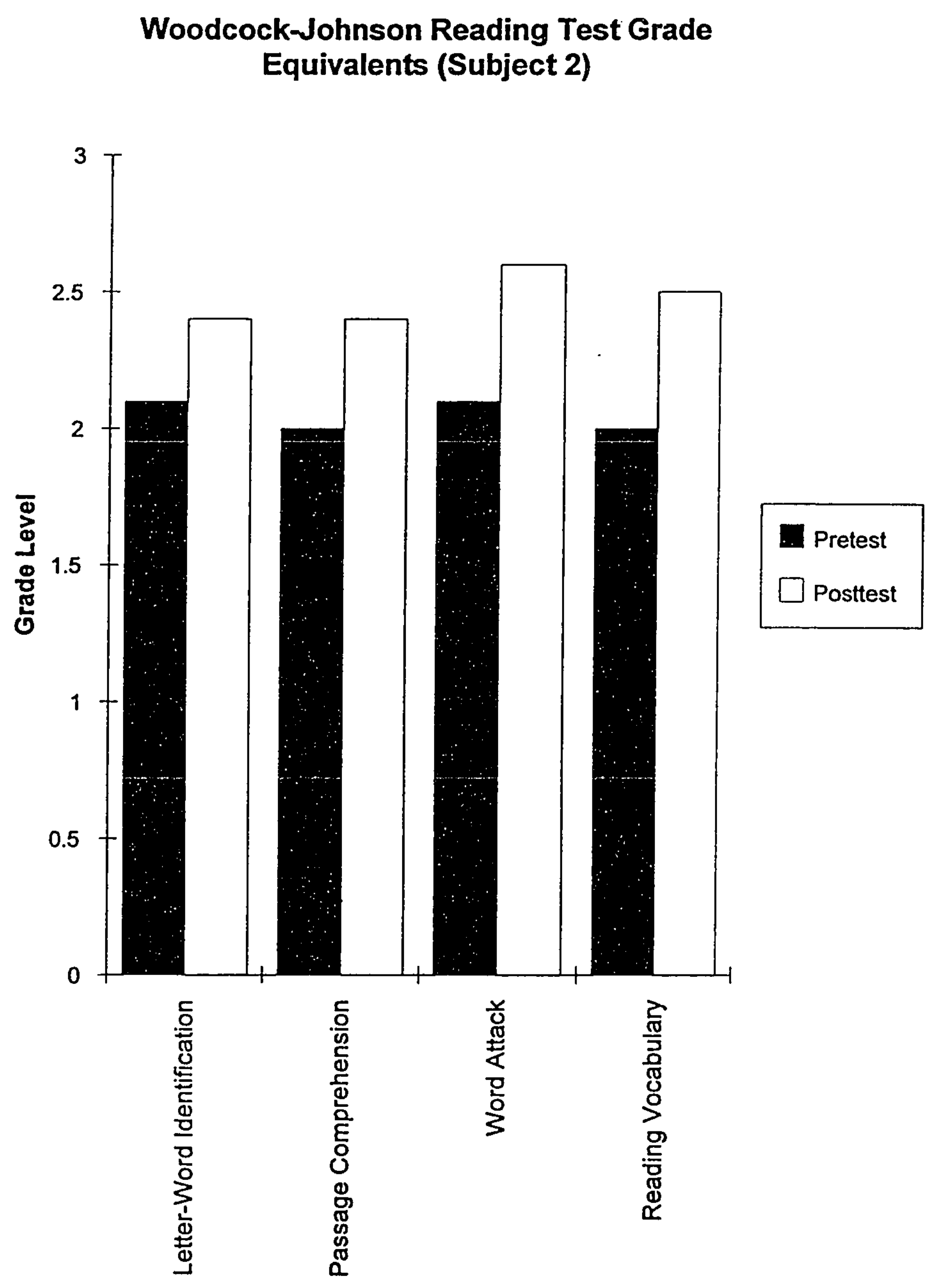
	Pretest	Posttest
Letter-Word Identification	2.1	2.4
Passage Comprehension	2.0	2.4
Word Attack	2.1	2.6
Reading Vocabulary	2.0	2.5

Table 8

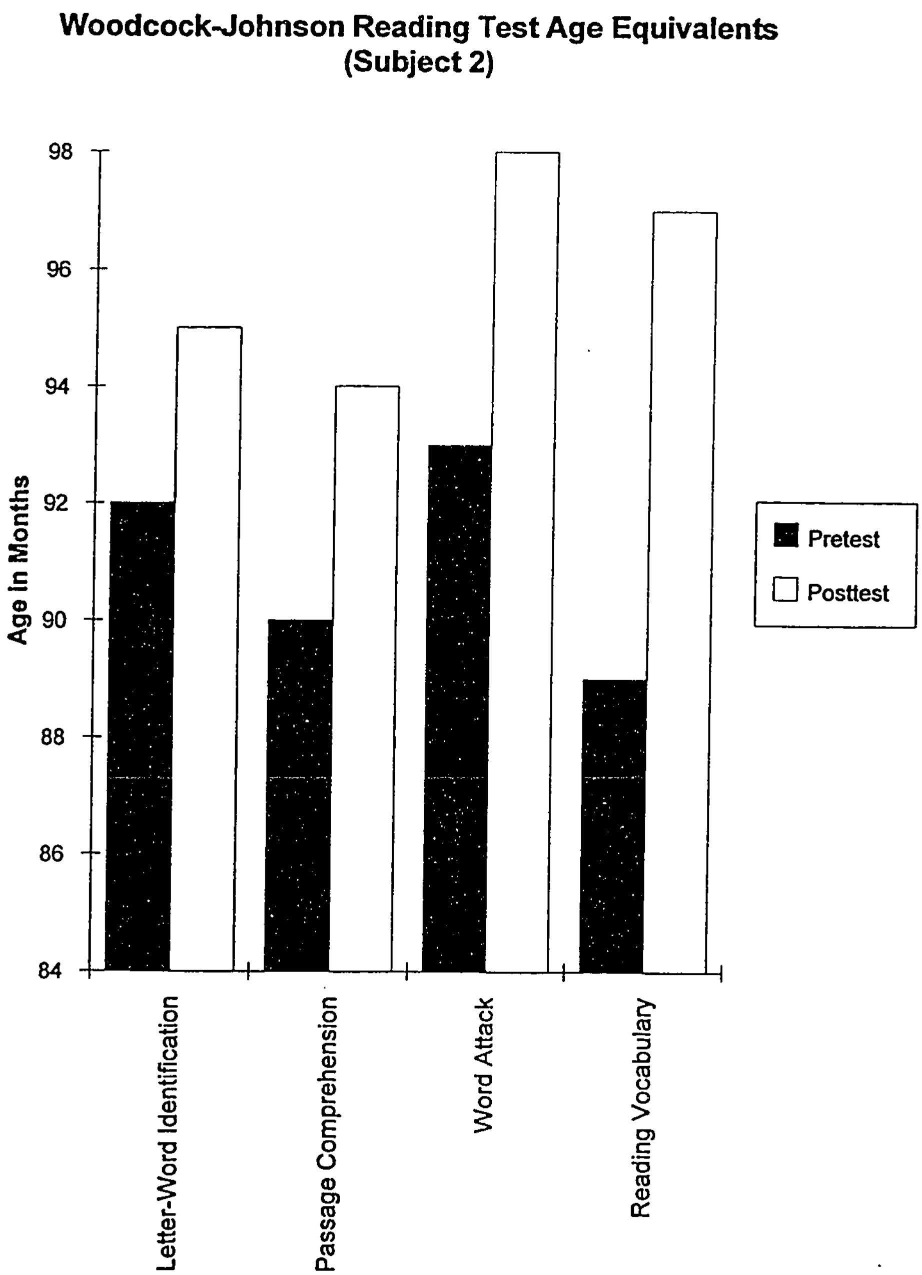
Woodcock-Johnson Reading Test Age Equivalents

	Pretest	Posttest
Letter-Word Identification	7-8	7-11
Passage Comprehension	7-6	7-10
Word Attack	7-9	8-2
Reading Vocabulary	7-5	8-1

Graph 7


Woodcock-Johnson Reading Test Grade Equivalents (Subject 2)
Grade Level
3
2.5
2
1.5
1
0.5
0
Letter-Word Identification
Passage Comprehension
Word Attack
Reading Vocabulary
Pretest
Posttest

Graph 8


Woodcock-Johnson Reading Test Age Equivalents
(Subject 2)
98
96
94
92
90
88
86
84
Age in Months
Letter-Word Identification
Passage Comprehension
Word Attack
Reading Vocabulary
Pretest
Posttest

Observable Behaviors and Comments from Subject 2

Pretest. During the pretesting, J.H. was very quiet and exhibited poor eye contact with the examiner. He would cooperate with activities which were asked of him but he would not look directly at the examiner and did not show much emotion or engage in much conversation. When given the Southern California Postrotary Nystagmus Test, Subject 2 maintained his balance while turning on the board, exhibited steady head control, did not indicate any experience of vertigo or dizziness, and he did not complain of nausea. J.H. expressed definite pleasure from rotation.

Intervention Period. J.H.'s behavior changed dramatically throughout the intervention period. Initially he was very quiet, had very poor eye contact, did not engage in much conversation other than answering questions which were asked of him. When engaging in the intervention activities he appeared to enjoy them as was evidenced by him asking to be able to complete them again after he was finished with one session. He did appear to be somewhat clumsy with activities. When jumping on the trampoline he did not want the researcher to hold onto his hand, he wanted to jump very high all by himself. When going down the ramp on the scooterboard he wanted to go faster and farther. His favorite activity by far was the barrel activity. He did express some dizziness with this activity and whenever he engaged in this activity he always wanted to go faster. He would say "Faster, faster, push me faster!". He also expressed that it would be fun to roll down a hill in the barrel. He consistently tried to get the researcher to allow him to roll in the barrel farther and longer than the allotted time. J.H.'s eye contact improved throughout the intervention period. He initiated more conversation with the researcher and expressed his feelings and discussed his daily activities. Initially he appeared to be very judgemental about his performance with activities. He would frequently make comments about how he could not perform some of the activities well, and became easily discouraged when he would not do something right the first time. This behavior became less evident approximately halfway through the study. He was very competitive and always wanted to do all the activities first before his classmate.

Posttest. J.H. cooperated well on the posttest as he did with the pretest. He was more talkative and made better eye contact during the posttest than with the pretest. During the posttest J.H. maintained his balance while turning, had steady head control, did not indicate any experience with vertigo, no dizziness, nausea, alarm or threat was noted, he did experience definite pleasure from rotation.

When attempting the letter-word identification he tried to sound out the words more skillfully than he had previously. It appeared that he was breaking down the word trying to scan it and sound out the word, rather than just trying to look at it and read it. He did get somewhat frustrated when he was unable to complete a word. During another part of the test (the reading vocabulary) he reversed letters of some words, for example instead of saying "on" he said "no". He could read and sound out a word but not know the meaning.

Results

The research questions generated for this study were:

1. Does vestibular stimulation increase reading comprehension in children with learning disability and accompanying vestibular dysfunction?
2. Does vestibular stimulation increase reading recognition in children with learning disability and accompanying vestibular dysfunction?
3. Does vestibular stimulation increase word attack skills in children with learning disability and accompanying vestibular dysfunction?

In response to the research questions, there was a small improvement in reading comprehension, reading recognition, and word attack skills in children with learning disability and accompanying vestibular dysfunction. No tests of significance could be performed due to the size of the sample.

The Southern California Postrotary Nystagmus Test Scores indicated an increase in duration of postrotary nystagmus, which suggests improvement in vestibular function which is believed to be related to the target skills. The pretest scores showed a total of 10 - 18 seconds duration and posttest showed 20 - 25 seconds duration. The smallest percentage increase was 39% total and the largest was 100% total. Subject 2 had a higher total postrotary nystagmus duration increase (100% versus 39% of subject 1), (see Table 9).

The Woodcock-Johnson battery indicated that the two subjects showed an improvement in reading skills. The pretest scores ranged from 452 to 477. Posttest scores ranged from 463 to 484. The smallest percentage of increase was 0% in word attack skills. The greatest percentage of increase was 3% improvement in passage comprehension (see Table 10). Passage comprehension showed the greatest percentage increase for both subjects (3% and 2% increase). Word attack exhibited the lowest for both subjects (0% and 1% increase).

Table 9

Southern California Postrotary Nystagmus Test Scores

	Subject	Pretest	Posttest	Percent Increase
Rotation to the Left	1	11 sec	11 sec	0%
	2	5 sec	10 sec	100%
Rotation to the Right	1	7 sec	14 sec	100%
	2	5 sec	10 sec	100%
Total	1	18 sec	25 sec	39%
	2	10 sec	20 sec	100%

Table 10

Woodcock-Johnson Reading Test Scores

	Subject	Pretest	Posttest	% change
Letter-Word Identification	1	460	466	1%
	2	457	463	1%
Passage Comprehension	1	452	466	3%
	2	461	470	2%
Word Attack	1	475	477	0%
	2	477	484	1%
Reading Vocabulary	1	460	467	2%
	2	467	477	2%

Grade equivalents for reading scores also exhibited improvements. Grade equivalent pretest scores ranged from 1.6 to 2.3. The posttests ranged from 2.0 to 2.6. The smallest grade level improvement was one month and the largest was a six month change. (see Table 11). Subject 1 demonstrated the largest grade level change with passage comprehension (6 month improvement). Subject 2 demonstrated the greatest improvement with word attack and reading vocabulary (5 month improvement).

Age equivalents as well showed improvements. Pretest scores ranged from 7-1 to 7-10. Posttest scores ranged from 7-5 to 8-2. The smallest age level change was a 2 month improvement and the largest was a 9 month improvement. (see Table 12). Subject 1 demonstrated the greatest age level improvement with passage comprehension (4 month) and subject 2 with reading vocabulary (9 months).

Table 11

Woodcock-Johnson Reading Test Grade Equivalents

	Subject	Pretest	Posttest	Grade Level Improvement
Letter-Word Identification	1	2.3	2.6	3 mo
	2	2.1	2.4	3 mo
Passage Comprehension	1	1.6	2.2	6 mo
	2	2.0	2.4	4 mo
Word Attack	1	2.0	2.1	1 mo
	2	2.1	2.6	5 mo
Reading Vocabulary	1	1.7	2.0	3 mo
	2	2.0	2.5	5 mo

Table 12

Woodcock-Johnson Reading Test Age Equivalents

	Subject	Pretest	Posttest	Age Level Improvement
Letter-Word Identification	1	7-10	8-1	4 mo
	2	7-8	7-11	4 mo
Passage Comprehension	1	7-2	7-8	6 mo
	2	7-6	7-10	4 mo
Word Attack	1	7-7	7-9	2 mo
	2	7-9	8-2	6 mo
Reading Vocabulary	1	7-1	7-5	4 mo
	2	7-5	8-1	9 mo

When the four subtests on the reading test were averaged to find a total reading score, Subject 2 showed a slightly higher percentage change (1.7%) than Subject 1 (1.5%). (see Table 13).

When examining total averaged grade equivalents, subject 2 showed a slightly higher grade level improvement (4 months) than Subject 1 (3 months). (see Table 14).

Subject 2 also showed a slightly higher age level improvement on total reading scores (5 months) versus 4 months of Subject 1. (see Table 15).

Table 13

Total Woodcock-Johnson Reading Test Scores

Subject	Pretest	Posttest	% change
1	462	469	1.5
2	466	474	1.7

Table 14

Total Woodcock-Johnson Reading Test Grade Equivalents

Subject	Pretest	Posttest	Grade Level Improvement
1	1.9	2.2	3 mo.
2	2.1	2.5	4 mo.

Table 15

Total Woodcock-Johnson Reading Test Age Equivalents

Subject	Pretest	Posttest	Age Level Improvement
#1	7-5	7-9	4 mo.
#2	7-7	8-0	5 mo.

CHAPTER FIVE

RESULTS AND DISCUSSION WITH IMPLICATIONS FOR OCCUPATIONAL THERAPY

The purpose of this study was to examine the effects of vestibular stimulation on reading skills in children who have reading difficulties and vestibular system dysfunction. The purpose was to determine if a program of vestibular stimulation would improve reading comprehension, reading recognition, and word attack skills in children with reading disability and vestibular dysfunction.

The research methodology was ABA design using a pretest, continuous documentation and posttest with subjects serving as their own controls. The subjects underwent eight weeks of vestibular stimulation (jumping, spinning, and sliding) administered 20 to 30 minutes three times per week and were then given a posttest at the end of the school session.

This study utilized learning handicapped children at Madison Elementary school. This school and subsequent class was chosen because of suggestions by educational professionals who stated that this was a site where there were learning handicapped children who might be appropriate for the study. The students were then chosen on the basis of their reading difficulties and scores on the pretests.

The researcher utilized a single subject research design since this is most like individualized treatment in occupational therapy. Continuous monitoring of subjects and observable behaviors and comments could be documented. Intervention techniques could be monitored and altered if a need arose.

Discussion of Results

This study was undertaken to examine the effects of vestibular stimulation on reading skills in children with learning disability accompanied by vestibular dysfunction. The results indicated that there was an improvement in reading scores as measured by the Woodcock-Johnson Reading Test as well as an increase in duration of postrotary nystagmus over pretest scores. Although the change in scores was small, it was in the expected direction.

The findings of this study are complimentary to the research originally conducted by Ayres which showed a relationship between vestibular stimulation and improved academic skills, including reading (Ayres, 1972a). Subjective findings (the continuous documentation of each treatment session) of the individual students exhibited changes which also supported the belief that vestibular stimulation can be used to improve reading skills.

Throughout the intervention period the students became more motivated to engage in the activities and appeared to integrate them and enjoy engaging in them more. The students showed the need for increased vestibular input as evidenced by wanting to complete as much of the vestibular activities as possible and use equipment for longer time periods and at greater speeds than when intervention began. During the course of the study the subjects made comments in reference to the treatment activities; they enjoyed being in the barrel and asked to roll down a steep hill, be pushed faster, jump really high on the trampoline, and go fast down the ramp by themselves.

The subjective findings also showed that the subjects' attitudes toward reading on the pretest and posttest changed. The subjects' reading scores improved between pretest and posttest. The subjects also showed quality improvements. They appeared to attempt to read the words with more skill. They could sound out the words, which they did not attempt to do on the pretest.

The attitudes and behaviors of both subjects changed during the intervention period. Subject 2 especially showed a change. Subject 2 was a large child for his age and appeared somewhat awkward and clumsy with gross motor activities. He had limited reading skills, when he initially began the study he exhibited poor eye contact and communication with the examiner. He made comments such as "I can't do it" or "I am no good at this". Throughout the course of the study he blossomed. He became much more talkative, eye contact improved dramatically and he became somewhat more confident with activities, although he continued to make negative comments about himself at times. His reading scores changed and he appeared to try to sound out words and attempt to read words better than during the pretest as described above.

The subjective findings appeared to substantiate the belief that a program of vestibular stimulation can help to improve reading skills in children with learning disability. The scores of the subjects on the pretest and posttest of reading skills showed small changes. Although the subjective findings appeared to support this belief the changes may not be an outcome of the vestibular stimulation. The improvements could be due to maturation of the subjects over time. Subjects could have scored higher on the posttests by chance. The subject group was small (only two at the end of the study). The subjects may have become more comfortable with the researcher than initially allowing them to relax and concentrate during test taking and score higher than initially on tests. The length of the intervention program was short, a longer intervention period may have led to greater improvement in reading skills. A longer intervention period would have been difficult for this study due to the length of the school session.

Implications for Occupational Therapy

Reading difficulties are a problem that learning disabled children frequently have. The effect of having reading difficulties can be detrimental to children in the educational system. Reading is a large part of the academic system and difficulty in reading can keep children from advancing and completing their daily living skills successfully. Having a reading disability can have a negative effect on school skills, daily living skills and self-esteem of a child. Activity of daily living skills such as reading, writing, functioning in the community independently may be affected and consequently this may affect their social and self help skills. Occupational therapists are involved in sensory integrative treatment of children with learning disability to help alleviate problems in this area and improve activities of daily living and school skills. Use of vestibular stimulation as a modality in treatment, along with classroom teaching should help academic and activity of daily living skills as well as social skills. This study examined the role of vestibular stimulation in reading skills and showed that it can be used as a means to improve reading. Further research needs to be conducted in this area to substantiate these findings.

Implications from this study suggest that future research is this area should take into consideration the recommendations to: 1) increase the number of subjects in the study to improve the possibiliies of determining statistical significance; 2)increase the length of the intervention program to determine if a longer time period of treatment will further improve the reading scores of the subjects; 3)develop a means to measure the long term outcome of the intervention, i.e. if reading skills continue to improve over a longer time span; 4)use of an equivalent control group which does not receive intervention to determine if it indeed was vestibular stimulation which improved reading skills.

In summary the study results suggested that vestibular stimulation can be used as a supplement to other therapy techniques and classroom remediation as a method for improving reading skills in children with learning disability. Results showed that there was improvement in reading skills after eight weeks of vestibular stimulation. Further research with a larger sample is recommended.

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Appendix A

Vestibular System

Anatomy of the Vestibular System

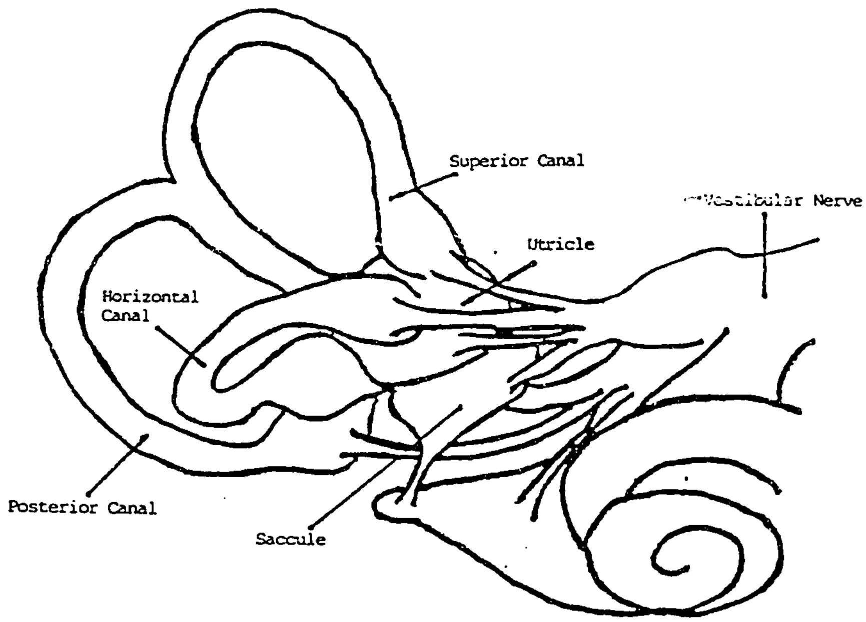
The semicircular canals, also called the kinetic labyrinth, detect movements of the head and have a special relationship to ocular movements in order to maintain visual fixation. The three semicircular canals lie in the three planes of space nearly at right angles to one another. The anterior and posterior semicircular canals lie in vertical planes. The lateral semicircular canal slopes downward at an angle of 30 degrees with the horizontal. The canals respond to movement, with their response being maximal when movement is in the plane of the canal (Barr, 1974; Parker, 1980; West, 1985).

Each canal has a bulge at one end called the ampulla which contains a patch of hair cells. These hair cells are what sense the movement of the head. The canals are filled with a fluid substance called endolymph. When the head moves the endolymph moves, affecting the hair cells which are located at one end of each canal. These hair cells are supplied with fine fibers from the vestibular nerve, which carries impulses to the brain (Parker, 1980; West, 1985).

There are two otolith organs - the utricle and saccule (the static labyrinth). The utricle monitors gravity and detects and measures linear accelerations and some vibration in nearly any plane. The precise function of the saccule in humans is unknown. There is speculation that it may have a role as a vertical accelerometer, or vibratory receptor (Fischer, Murray & Bundy, 1991; Parker, 1980; West, 1985).

The Vestibular Apparatus

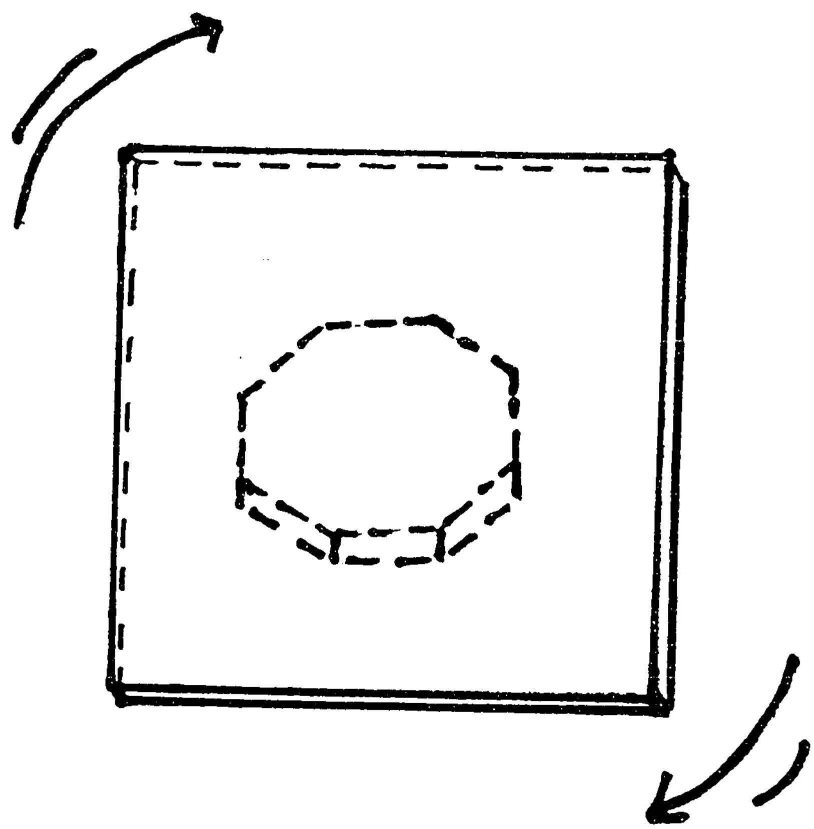
(Parker, 1980)



Appendix B

Spinning Board

100



Appendix C

Consent Form

SJSU SAN JOSE STATE UNIVERSITY

A campus of The California State University

School of Applied Arts and Sciences • Department of Occupational Therapy
One Washington Square • San José, California 95192-0059 • Main Office 408/924-3070 • Fieldwork Office 408/924-3078

AGREEMENT TO PARTICIPATE IN RESEARCH
SAN JOSE STATE UNIVERSITY

RESPONSIBLE INVESTIGATOR: Shelley McKeone

TITLE OF PROTOCOL: Case Studies of the Effects of Vestibular Stimulation on Reading Skills in Children with Learning Disability and Accompanying Vestibular Dysfunction.

Your child is invited to participate in a research study that is investigating the effects of movement on reading skills. The results of this study should further our understanding of whether or not stimulation of the vestibular system of a child with learning disability will have an effect on his/her reading skills.

I understand that

1) the study will consist of pretests, posttests which involve reading and spinning, and a treatment program. The treatment program will last for 8 weeks, with three 20 minute sessions per week. The treatment will involve spinning, jumping, and sliding. The study will be performed at Madison Elementary School.

2) The possible risks of this study are nausea resulting from spinning or sliding and risk of falling off the equipment used in the study (the scooterboard, or trampoline).

3) The possible benefits from the study are measurable changes in reading skills, and information of literature and activities related to the study which may be beneficial to my child.

4) The results from this study may be published, but any information from this study that can be identified with my child will remain confidential and will be disclosed only with my permission.

5) Any questions about my child's participation in this study will be answered by Shelley McKeone, home 274-7013/wk. 588-3145. Complaints about the procedures

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may be presented to Dr. Lela Llorens, (408) 924-3070. For questions or complaints about research subject's rights, or in the event of research-related injury, contact Serena Stanford, Ph.D. (Associate Academic Vice President for Graduate Studies & Research) at (408) 924-2480.

6) My consent is given voluntarily without being coerced; my child may refuse to participate in this study or in any part of this study, and I may withdraw my consent at any time, without prejudice to my relations or my child's with SJSU, and Madison Elementary School.

7) I have received a copy of this consent form for my file.

HAVING READ THE INFORMATION PROVIDED ABOVE, I HAVE MADE A DECISION WHETHER OR NOT MY CHILD MAY PARTICIPATE. MY SIGNATURE INDICATES THAT <u>MY CHILD MAY PARTICIPATE</u> AND <u>IS WILLING TO PARTICIPATE</u>.

______ DATE

______ PARENT'S/GUARDIAN'S SIGNATURE

______ CHILD'S NAME

______ RELATION TO CHILD

______ INVESTIGATOR'S SIGNATURE

Appendix D
Intervention Procedures

Spinning

The child will lay in a carpeted barrel. The child will be rolled to the right 10 times, and to the left 10 times with a one minute break in between.

Sliding

The child will lie on his/her stomach on a scooter board and will slide down a ramp 10 times.

Jumping

The child will jump vertically 20 times.